Frontier Observatory for Research in Geothermal Energy – Milford Site, Utah

Task 2A.2 – NEPA, Summary of Environmental Impacts

February 10, 2017

SUMMARY OF ENVIRONMENTAL IMPACTS

The following table summarizes the impacts anticipated for each of the activities that will be conducted in Phases 2B, 2C and 3.

In all cases, Best Management Practices (BMPs) and A Stormwater Pollution Prevention Plan (SWPPP), and mitigation practices will be employed.

BMPs: Best Management Practices will be employed to ensure safe, professional and environmentally sound operations. The Utah FORGE project will collaborate with the DOE and other project stakeholders and engage consultants, contractors and suppliers with proven records in their fields. Drilling contractors seasoned in geothermal drilling will bring the experience critical to successful drilling projects, including, but not limited to selection of the drill rig, mud pumps and auxiliary equipment suited to the planned operations.

SWPPP: A Stormwater Pollution Prevention Plan (SWPPP) will be developed to support permits to be obtained from the Utah Department of Water Resources and Beaver County.

Environmental Mitigation*: Mitigation measures that have been developed to avoid or reduce impacts to natural resources in geothermal operations will be integrated into the planning, operating and reclamation phases. The most effective environmental mitigation is to identify site-specific issues early and, where possible, avoid by changing plans/sites – and by reducing surface disturbance such as by drilling more than one well from a single pad. The Utah FORGE team will coordinate with the DOE, BLM, and SITLA NEPA staff in these efforts.

Following are selected sources/compilations of Best Management Practices (BMPs), Standard Operating Procedures (SOPs), and Mitigation practices. Every project and location is different. Existing NEPA EAs for geothermal projects are also good sources of reference for approaches to BMPs and mitigation measures.

Winnemucca District RMP/EIS: Winnemucca District Office Best Management Practices and Standard Operating Procedures Appendix B.

BLM 2006: Instruction Memorandum No. 2007-021 – Integration of Best Management Practices into Application for Permit to Drill Approvals and Associated Rights-of-Way

Health, Safety and Emergency Response Plans (Safety Plans): The Utah FORGE project will employ Health, Safety and Emergency Response Plans in compliance with federal OSHA and Utah regulations, CERLCLA, Emergency Planning and Community Right to Know Act (EPCRA) and local fire ordinances and rules. Typically, the drilling contractor also maintains its own Plans under which its employees operate. The Utah FORGE team will ensure coordination with the driller plans. Emergency medical, fire, sheriff, and stakeholder management and supervisory phone numbers will be posted at the rig, at each trailer, in the office, and copied to cognizant stakeholders. The plan will cover, but not limited to training of personnel in safety procedures, location of personal safety equipment and Materials Safety Data Sheets (MSDS), safe locations, emergency phone numbers, and other matters and will cover: Medical response, fire, blowout response, H2S monitoring and response, working in confined spaces, lightning

and windstorms, spill response, handling of hazardous/toxic materials, working around hot or moving equipment, vehicle accident response and agency reporting requirements.

Field Rules: Utah FORGE management will also employ Field Rules for working in the Office or at the FORGE EGS site, to cover: speed limits, smoking, parking, no wandering offsite, no dogs, liquor or guns, no hunting, no gathering of cultural/archeological materials, access to keys, office and lab, requirements for visiting the rig (no tennis shoes, wear hard-toe shoes, hardhats, ear protection during drilling), understand safety rules), to whom to refer public inquiries, etc.

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*Mitigation From: Council on Environmental Quality NEPA Regulations (40 CFR Parts 1500-1508):

§1508.20 Mitigation.

"Mitigation" includes:

(a) Avoiding the impact altogether by not taking a certain action or parts of an action.

(b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation.

(c) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.

(d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.

(e) Compensating for the impact by replacing or providing substitute resources or environments.

Activity	Air Quality	Water Quality	Soils/ Geology	Land Use	Solid/ Hazardous Waste	Human Health and Safety	Biological Resource	Socio-economic	Historic/ Cultural	Aesthetic
Construction of drill pads	Negligible impact. Temporary increase in dust and diesel exhaust. Dust control watering and gravel as needed.	Negligible impact. No surface waters. Groundwater not potable. A berm will be constructed around drill pad to contain spills.	Negligible impact. Pads A1 and A2 will be graded and graveled. Sump will be lined. Pad will be surrounded by a berm for erosion control. Soil will be stockpiled for site reclamation.	Negligible impact. Construction will comply with Beaver Co. zoning and BLM and state regulatory agency requirements. Site reclaimed at project termination. Pads will occupy up to 13.4 acres, or 10.3% of total potential disturbed acreage.	Negligible impact. Wastes controlled in lined earthen pit and tanks on site, tested and removed offsite if required. No hazardous waste anticipated based on nearby drilling and construction activities.	Negligible impact. Health, Safety and Emergency Response Plans in place. Construction by state approved contractors. Equipment operator licenses required of all construction personnel.	Negligible impact. Temporary site occupancy. Construction activities will comply with BLM requirements. Site will be re-seeded.	Minor impact. Small positive temporary increase in population, employment, sales and tax base.	Negligible impact. Archeolo-gical surveys conducted with finding of no significant impact. SITLA and BLM concur; SHPO concur-rence pending.	Negligible impact. No sensitive viewpoints. Construction will comply with Beaver Co. zoning and BLM and state regulatory agency requirements.

Activity	Air Quality	Water Quality	Soils/ Geology	Land Use	Solid/ Hazardous Waste	Human Health and Safety	Biological Resource	Socio-economic	Historic/ Cultural	Aesthetic
Road grading/graveling	Negligible impact. Temporary dust and diesel exhaust. Dust control, watering and graveled as needed.	Negligible impact. No surface waters. Ground water not potable.	Negligible impact. Travel limited to existing roads. Roads graveled and bladed as needed to reduce damage by heavy equipment.	Negligible impact. Travel on existing roads. Improvements will comply with Beaver Co. zoning and BLM and state regulatory agency requirements. Roads represent up to 5.7 acres, or 4.4% of total potential disturbed acreage.	Negligible impact.	Negligible impact. Health, Safety and Emergency Response Plans in place. Appropriate equipment operator licenses required.	Negligible impact. Temporary increase in noise and vehicle traffic. Activities will comply with BLM requirements.	Minor impact. Small positive temporary increase in population, employment, sales and tax base.	Negligible impact. Existing roads already disturbed. Archeological survey indicate activities will not result in new cultural disturbances. SITLA and BLM concurrence; SHPO approval pending.	Negligible impact. No sensitive viewpoints. Construction activities will comply with Beaver Co. zoning and BLM and state regulatory agency requirements.

Activity	Air Quality	Water Quality	Soils/ Geology	Land Use	Solid/ Hazardous Waste	Human Health and Safety	Biological Resource	Socio-economic	Historic/ Cultural	Aesthetic
Drilling one 7,000 ft. test well	Negligible impact. Temporary effect on graveled pad from diesel generator exhaust and equipment using roads. Drilling and testing activities up to 24 hours/day for up to 85 days. See *Attachment 1* for estimates of emissions.	Negligible impact. Well design approved by State Engineer. Ground-water not potable. Well cased through shallow ground-water aquifers. Drilling fluids and cuttings contained in lined sump or tanks.	Negligible impact. Well drilled on existing pad. Drilling fluids and borehole cuttings contained on site in lined sump.	Negligible impact. Well located on existing drill pad. Drilling will comply with Beaver Co. zoning and state regulatory agency requirements. Well abandoned as per land owner and State Engineer requirements at project termination.	Negligible impact. Cuttings and drilling fluid contained on site in lined sump or tanks. Removed if hazardous. Pad reclaimed at project conclusion. See *Attachment 2* for estimates of volumes of waste.	Negligible impact. Potential of H_2S discharges low based on nearby drilling, but will be monitored. Temporary increase in noise. Health, Safety and Emergency Response Plans in place. Appropriate safety equipment and training required of all personnel. Drilling supervisor will conduct daily safety meetings and ensure compliance with all safety requirements by on site personnel. Contractor selection will include evidence of safe work practices. See *Attachment 3* for estimates of noise levels.	Negligible impact. Operations on existing drill pad. Temporary increase in noise from drilling operations and traffic. All activities will comply with BLM require-ments. Fluid storage containers fenced and netted as necessary to exclude wildlife.	Minor impact. Small positive temporary increase in population, employment, sales and tax base.	Negligible impact. Drilling to occur on existing pads.	Negligible impact. No sensitive viewpoints. Drill rig and equipment on site for less than 3 months of full 8 year project. Activities will comply with Beaver Co. zoning and state regulatory agency require-ments.

Activity	Air Quality	Water Quality	Soils/ Geology	Land Use	Solid/ Hazardous Waste	Human Health and Safety	Biological Resource	Socio-economic	Historic/ Cultural	Aesthetic
Drilling deep injection/production couplet EGS wells	Negligible impact. Temporary effect on graveled pad from diesel generator exhaust and equipment using roads. Drilling activities up to 24 hours/day for 4 months in each of 2 years. See *Attachment 4* for estimates of emissions.	Negligible impact. Well design approved by State Engineer. Ground-water not potable. Well cased through shallow ground-water aquifers. Drill fluids and cuttings contained in lined sump or tanks.	Negligible impact. Well drilled on existing pad. Drilling fluids and borehole cuttings contained on site in sump.	Negligible impact. Well located on existing drill pad. Drilling will comply with Beaver Co. zoning and BLM and state regulatory agency requirements. Well abandoned as per land owner and State Engineer requirements at project termination.	Negligible impact. Cuttings and drilling fluid contained on site in lined sump or tanks. Removed if hazardous. Pad reclaimed at project conclusion. See *Attachment 5* for estimates of volumes of waste.	Negligible impact. Potential of H_2S discharges low, based on nearby drilling, but will be monitored. Temporary increase in noise. Health, Safety and Emergency Response Plans in place. Appropriate safety equipment and training required of all personnel. Drilling supervisor will conduct daily safety meetings and ensure compliance with all safety requirements by on site personnel. Contractor selection will include evidence of safe work practices. See *Attachment 6* for estimates of noise levels.	Negligible impact. Operations on existing drill pad. Temporary increase in noise from drilling operations and traffic. All activities will comply with BLM requirements. Fluid storage containers fenced and netted as necessary to exclude wildlife.	Minor impact. Small positive temporary increase in population, employment, sales and tax base.	Negligible impact. Drilling to occur on existing pads.	Negligible impact. No sensitive view-points. Temporary effects due to drill rig and drilling equipment. Activities will comply with Beaver Co. zoning BLM and state regulatory agency require-ments.

Activity	Air Quality	Water Quality	Soils/ Geology	Land Use	Solid/ Hazardous Waste	Human Health and Safety	Biological Resource	Socio-economic	Historic/ Cultural	Aesthetic
Drilling three 1,000 ft. water wells	Negligible impact. Diesel exhaust from truck-mounted drill rig up to 10 hours/day for up to 1 month. See *Attachment 7* for estimates of emissions.	Negligible impact. Groundwater not potable. Well design approved by State Engineer. Drilling fluids will be mixed, used and kept in a self-contained circulating system. Cuttings will be collected on site, tested for hazardous materials and if not hazardous as expected, used as material for local construction.	Negligible impact. Drilling fluids will be mixed, used and kept in a self-contained circulating system. Cuttings will be collected on site, tested for hazardous materials and if not hazardous as expected, used as material for local construction.	Negligible impact. Surface disturbance less than about 50 x 50 ft per well. Activities will comply with Beaver Co. zoning and state regulatory agency requirements. Depending on which site is chosen, the water well field will occupy 5.6 or 8.7 acres (or 4.3% to 6.6% of total potential disturbed acreage).	Negligible impact. Drill fluids will be mixed, used and kept in a self-contained circulating system. Cuttings will be collected on site, tested for hazardous materials and if not hazardous as expected, used as material for local construction. See *Attachment 8* for estimates of volumes of waste.	Negligible impact. Health Safety and Emergency Response Plans in place. Appropriate safety equipment and training required of all personnel. Drilling supervisor will ensure safe operations on site. Small, temporary increase in noise expected from truck mounted rigs designed for drilling in suburban environments.	Negligible impact. Operations on small pad. Temporary increase in noise and traffic during drilling. All activities will comply with BLM require-ments. Fluid storage containers fenced and netted as necessary to exclude wildlife.	Minor impact. Small positive temporary increase in population, employ-ment, sales and tax base.	Negligible impact. Archeologi-cal surveys conducted with finding of no significant impact. SITLA and BLM concur; SHPO concurrence pending.	Negligible impact. No sensitive view-points. Activities will comply with Beaver Co. zoning and state regulatory agency require-ments.

Activity	Air Quality	Water Quality	Soils/ Geology	Land Use	Solid/ Hazardous Waste	Human Health and Safety	Biological Resource	Socio-economic	Historic/ Cultural	Aesthetic
Drilling ten 500 ft. seismic monitoring wells	Negligible impact. Diesel exhaust from truck-mounted drill rig 8 hours/day for approximate-ly 2 months. See *Attachment 9* for estimates of emissions.	Negligible impact. Drilling fluids will be mixed, used and kept in a self-contained circulating system. Cuttings will be collected on site, tested for hazardous materials and if not hazardous as expected, used as material for local construction. Wells cased.	Negligible impact. Drilling fluids will be mixed, used and kept in a self-contained circulating system. Cuttings will be collected on site, tested for hazardous materials and if not hazardous as expected, used as material for local construction.	Negligible impact. Surface disturbance less than approximately 50 x 50 ft. per well. Activities will comply with Beaver Co. zoning and state regulatory agency requirements. Sites will occupy up to 0.6 acres, or 0.4% of total potential disturbed acreage.	Negligible impact. Drill fluids will be mixed, used and kept in a self-contained circulating system. Cuttings will be collected on site, tested for hazardous materials and if not hazardous as expected, used as material for local construction. See *Attachment 10* for estimates of volume of cuttings.	Negligible impact. Health Safety and Emergency Response Plans in place. Appropriate safety equipment and training required of all personnel. Drilling supervisor responsible for site safety. Small, temporary increase in noise expected from truck mounted rigs designed for drilling in suburban environ-ments.	Negligible impact. Temporary increase in noise and traffic during drilling. All activities will comply with BLM require-ments. Fluid storage containers fenced and netted as necessary to exclude wildlife.	Minor impact. Small positive. Temporary increase in population, employ-ment, sales and tax base.	Negligible impact. Archeolo-gical surveys will be conducted and sites approved by BLM, SITLA and SHPO.	Negligible impact. No sensitive viewpoints. Activities will comply with Beaver Co. zoning and state regulatory agency require-ments.

Activity	Air Quality	Water Quality	Soils/ Geology	Land Use	Solid/ Hazardous Waste	Human Health and Safety	Biological Resource	Socio-economic	Historic/ Cultural	Aesthetic
Office w/ lab, fenced storage and septic tank	Negligible impact. Temporary increase in dust and diesel exhaust due to construction. Site graded and graveled as appropriate to minimize dust. Minor, intermittent vehicle traffic possible by visitors and researchers.	Negligible impact. Groundwater at site not potable. Facilities will include an approved septic tank and water well approved by the State Engineer. Bottled water provided for human consumption.	Negligible impact. Office built on 2-acre near-level site. Site on private land. Will be reclaimed per owner's instructions. Any removed soil will be stockpiled for later reclamation of site as requested by site owner.	Negligible impact. Construction approved by Beaver County. Site will occupy 1.6 acres or 1.2% of total potential disturbed acreage.	Negligible impact. Septic system will comply with all permits and regulations.	Negligible impact. Temporary increase in noise during building. Health Safety and Emergency Response Plans in place. Fence, cameras and lighting installed around compound. Appropriate safety equipment and training provided at office site and required of all personnel working or visiting FORGE facilities. Facilities locked when not in use.	Negligible impact. Temporary increase in noise and traffic during construction. Vegetation from up to two-acres removed.	Minor impact. Small positive temporary increase in population, employment, sales and tax base.	Negligible impact. Archeological surveys conducted with finding of no significant impact. SITLA and BLM concur; SHPO concurrence pending.	Negligible impact. No sensitive viewpoints. Activities will comply with Beaver Co. zoning and state regulatory agency requirements.

Activit	Air Quality	Water Quality	Soils/ Geology	Land Use	Solid/ Hazardous Waste	Human Health and Safety	Biological Resource	Socio-economic	Historic/ Cultural	Aesthetic
Electric Power Line/Water Pipeline	Negligible impact. Electric power line and water pipeline will occupy same utility corridor originating at the office site. Temporary increase in dust and diesel emissions. Power line construction contracted to Rocky Mountain Power.	Negligible impact. Extend culvert across mostly dry washes if needed, unless line already built by others.	Negligible impact. Construction along existing road ROW, unless line already built by others.	Negligible impact. Activities will comply with Beaver Co. zoning and BLM and state regulatory agency requirements. The utility corridor will occupy up to 86 acres (based on 100 ft. easement), or 66% of total potential disturbed acreage. Actual disturbed land will be much less if only pipe line occupies corridor.	Negligible impact. None anticipated.	Negligible impact. Common construction field work. Construction contracted to Rocky Mountain Power. Temporary increase in noise during construction. Rocky Mountain Power will be responsible for safety and health of workers in accordance with established state utility Health Safety and Emergency Response Plans.	Negligible impact. Temporary increase in noise and traffic during construction. Vegetation removed at intervals for power poles, unless built by others. Disturbance from 6 inch pipeline laid on ground will be negligible. All activities will comply with BLM requirements.	Minor impact. Small positive temporary increase in population, employment, sales and tax base.	Negligible impact. Archeological surveys of utility corridor conducted with finding of no significant impact. SITLA and BLM concur; SHPO concurrence pending.	Negligible impact. No sensitive viewpoints. Construction will comply with Beaver Co. zoning and BLM and state regulatory agency requirements.

Activity	Air Quality	Water Quality	Soils/ Geology	Land Use	Solid/ Hazardous Waste	Human Health and Safety	Biological Resource	Socio-economic	Historic/ Cultural	Aesthetic
Fiber Optic Cable (One mile Extension of SunEdison line to office)	Negligible impact. One mile extension of cable to office. Minor dust and diesel exhaust during installation. Installation contracted through cable owner.	Negligible impact. No impact to water quality.	Negligible impact. Trenched install unless hung on power lines.	Negligible impact. Installation will comply with Beaver Co. zoning and BLM and state regulatory agency requirements. Up to 1.6 acres, or 1.3% of the total potential disturbed acreage could be affected.	Negligible impact. None anticipated.	Negligible impact. Common construction field work. Installation contracted through cable owner.	Negligible impact. Temporary increase in noise and traffic. All activities will comply with BLM requirements.	Minor impact. Small positive. temporary increase in population, employment, sales and tax base	Negligible impact. Depending on installation, archeological surveys may be required by the BLM, SITLA and SHPO.	Negligible impact. No sensitive viewpoints. Construction will comply with Beaver Co. zoning and BLM and state regulatory agency requirements.

Activity	Air Quality	Water Quality	Soils/ Geology	Land Use	Solid/ Hazardous Waste	Human Health and Safety	Biological Resource	Socio-economic	Historic/ Cultural	Aesthetic
Geophysical Surveys (gravity, MT, TDEM)	Negligible impact. Light traffic on existing roads to reach sites may be required. Individual surveys will be completed within approximately 2 weeks.	Negligible impact. No water quality impacts.	Negligible impact. Very short term site occupancy of less than 24 hours. Vehicle traffic restricted to existing roads. Equipment moved cross-country on foot. Very small holes reclaimed.	Negligible impact. Maximum individual site occupancy limited to 24 hours. Activities will comply with BLM and state regulatory agency requirements.	Negligible impact. None anticipated.	Negligible impact. Very low risk to personnel.	Negligible impact. Surveys will comply with BLM requirements. No cross country vehicle traffic will be conducted. Little presence required in field after installation.	Minor impact. Small positive temporary increase in population, employment, sales and tax base	Negligible impact. Sites will be approved by BLM, SITLA and SHPO.	Negligible impact. No sensitive viewpoints. Activities will comply with BLM and state regulatory agency requirements.

Activity	Air Quality	Water Quality	Soils/ Geology	Land Use	Solid/ Hazardous Waste	Human Health and Safety	Biological Resource	Socio-economic	Historic/ Cultural	Aesthetic
Seismic Reflection Vibroseis Survey	Negligible impact. Very short term site occupancy by two vibroseis trucks. Survey completed within several weeks.	Negligible impact. Survey conducted in fall to avoid wet soils. No water quality impact.	Negligible impact. Survey conducted in fall to avoid damage to wet soils.	Negligible impact. Temporary site occupancy. Activities will comply with BLM and state regulatory agency requirements.	Negligible impact. None generated.	Negligible impact. Very low risk. Work contracted to seismic company. Field operations conducted by trained and qualified personnel.	Negligible impact. Survey to be conducted outside of nesting season as per BLM requirement. Some crushed grass/shrubs at intervals. No reclamation required. Activities will comply with BLM requirements.	Minor impact Small positive temporary increase in population, employment, sales and tax base	Negligible impact. Archeological surveys conducted with finding of no significant impact. SITLA and BLM concur; SHPO concurrence pending.	Negligible impact. No sensitive viewpoints. Activities will comply with Activities will comply with BLM and state regulatory agency requirements.

Activity	Air Quality	Water Quality	Soils/ Geology	Land Use	Solid/ Hazardous Waste	Human Health and Safety	Biological Resource	Socio-economic	Historic/ Cultural	Aesthetic
Geophysical Installation and Monitoring	Negligible impact. Limited vehicle traffic on existing roads or via ATVs will be required to reach sites. Equipment will be hand carried for from existing roads for seismometer installation.	Negligible impact. Presence of equipment in field will not impact water quality.	Negligible impact. Small footprints < 20 x 20 ft.	Negligible impact. Equipment and installation will comply with BLM and state regulatory agency requirements. The sites will occupy up to 0.4 acres, or 0.3% of total potential disturbed acreage.	Negligible impact. No hazardous waste generated.	Negligible impact. Very low risk during fieldwork and installation. Tiltmeter Installation conducted by Halliburton approved contractor. Periodic presence in field required to maintain equipment.	Negligible impact. Short term temporary presence in field. Installation of monitoring equipment will comply with BLM and/or regulating agency requirements.	Minor impact. Small positive temporary increase in population, employment, sales and tax base	Negligible impact. Archeological surveys will be conducted and sites approved by BLM, SITLA and SHPO. Equipment limited to approved sites.	Negligible impact. No sensitive viewpoints. Activities will comply with Beaver Co. zoning and BLM and state regulatory agency requirements.

Activity	Air Quality	Water Quality	Soils/ Geology	Land Use	Solid/ Hazardous Waste	Human Health and Safety	Biological Resource	Socio-economic	Historic/ Cultural	Aesthetic
Well Stimulation	Negligible impact. Temporary diesel exhaust from generators and pumps. See *Attachment 11* for estimated emissions.	Negligible impact. Groundwater used not potable. Stimulated zones will be below groundwater aquifers at depths greater than about 8000. Wells cased through groundwater aquifers.	Minor impact. Activities conducted on existing drill pad. Temporary potential deep induced micro-seismicity possible. Activities highly monitored. Induced seismicity plan in place.	Negligible impact. Activities conducted on existing drill pad.	Negligible impact. Standard stimulation chemicals will be used. Stimulation company to provide personnel to supervise and conduct activities.	Negligible impact. Potential minor micro-seismicity. Most not felt. Unpopulated area. Seismicity will be heavily monitored. DOE Induced seismicity plan in place. Ground motion and seismometers will be operational. Contractor will provide health and safety briefings to personnel. Stimulation supervisor will be responsible for site safety. Only trained personnel on site.	Negligible impact. Activities conducted on existing drill pad. Temporary increase in noise. Fluid storage containers fenced and netted as necessary to exclude wildlife.	Minor impact. Small positive temporary increase in population, employment, sales and tax base.	Negligible impact. Activities conducted on existing pad.	Negligible impact. No sensitive viewpoints. Activities will comply with Beaver Co. zoning and state regulatory agency requirements.

Activity	Air Quality	Water Quality	Soils/ Geology	Land Use	Solid/ Hazardous Waste	Human Health and Safety	Biological Resource	Socio-economic	Historic/ Cultural	Aesthetic
Construction of Evaporative or dry cooling facilities and piping	Negligible impact. Temporary increase in dust and diesel exhaust due to construction.	Negligible impact. No surface or potable groundwater present.	Negligible impact. Activities conducted on existing pad.	Negligible impact. Activities conducted on existing pad. Activities will comply with Beaver Co. zoning and state regulatory agency requirements.	Negligible impact. No hazardous material required or generated.	Negligible impact. Minor increase in traffic during construction. Hot water stored in appropriate containers. Potential Health, Safety and Emergency Response Plans in place. Only authorized, trained personnel allowed on site.	Negligible impact. Fluid storage containers fenced and netted as necessary to exclude wildlife.	Minor impact. Small positive temporary increase in population, employment, sales and tax base during construction of cooling facilities.	Negligible impact. Activities conducted on existing pad.	Negligible impact. No sensitive viewpoints. Construction will comply with Beaver Co. zoning and state regulatory agency requirements.

Activity	Air Quality	Water Quality	Soils/ Geology	Land Use	Solid/ Hazardous Waste	Human Health and Safety	Biological Resource	Socio-economic	Historic/ Cultural	Aesthetic
Heat Sweep Testing (injection of groundwater through fractures in deep hot rock and production of heated water up productions well)	Negligible impact. Temporary production of steam from heated groundwater in open pond or tanks if evaporative cooling used. No steam production if dry cooling used. Negligible exhaust from diesel powered pumps unless electric pumps used.	Negligible impact. Produced water to be injected below groundwater aquifers at depths >8000 ft for heat extraction. Water temperature and quality will be monitored.	Negligible impact. Activities conducted on existing pad. No new pipeline construction or additional soil disturbance required.	Negligible impact. Activities conducted on existing pad.	Negligible impact. Produced water will be recirculated.	Negligible impact. Hot water stored in appropriate containers. Potential Health, Safety and Emergency Response Plans in place. Only authorized, trained personnel allowed on site.	Negligible impact. Activities conducted on existing pad. Fluid storage containers fenced and netted as necessary to exclude wildlife.	Minor impact. Small positive temporary increase in population, employment, sales and tax base during testing.	Negligible impact. Activities conducted on existing pad.	Negligible impact. No sensitive viewpoints. No new construction or equipment required.

Key: Negligible impact/Minor Impact Moderate Impact Significant Impact

ATTACHMENT 1

Table 1 presents the estimated quantities of gases and particulate matter that would be produced by diesel engines during the drilling of the 7000 ft test well in Phase 2B. The calculations are based on a drill rig with equipment similar to the rig that will be contracted for the FORGE project. Table 3 and 4 provide details of engines used for the calculations.

Table 1. *Total Emissions produced during drilling in Phase 2B.*

CO_2 (ton)	NMHC (lb)	NOX (lb)	VOC (lb)	PM (lb)	CO (lb)
497	588	11414	611	317	3623
CO_2 (tonne)	NMHC (kg)	NOX (kg)	VOC (kg)	PM (kg)	CO (kg)
451	267	5176	277	143	1644

NMHC = non-methane hydrocarbons; NOX = nitrous oxides = VOC is volatile organic compounds; PM = particulate matter; CO = carbon monoxide.

Our estimates are compared to data recorded by West Virginia University's (WVU) Center for Alternative Fuels, Engines and Emissions (CAFEE) [1] in Figure 1. The data were taken from a drilling rig (MSEEL site), which utilized three Caterpillar 3512B generator units.

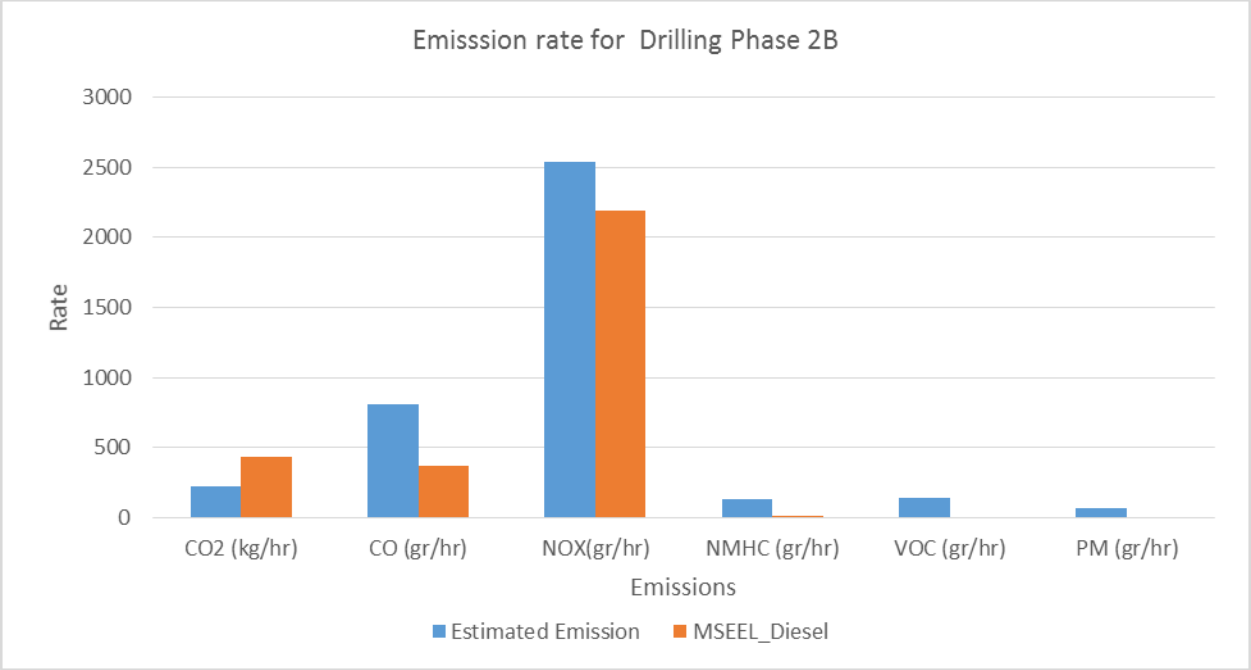


***Figure 1**. Compression between estimated emission rate for phase 2b and the recorded data from MSEEL site [1]*

Reference

[1] Johnson, D., and Heltzel, R. (2015), "MSEEL Site: Engine Fueling and Emissions from a Caterpillar 3512B Generator Set"

RIG SPECIFICATIONS

Consider the following rig specifications (subject to change).

- **Drilling Range:** 10,000' With 4- ½" Drill Pipe. 12,000' With 3- ½" Drill Pipe.
- **Drawworks:** Gardner Denver 500, 650 H.P., Powered by (2) -Detroit B -60 Series Diesel Engines, With a Parmac V -80 Hydromatic Brake.
- **Mast:** Dreco 126' Telescoping Treble Mast Rated at 500,000# GNC, Static Hook Load of 357,000# with 10 Lines.
- **Substructure:** Ideco 20' High With 500,000# Capacity.
- **Mud Pump #1:** RS-F-1000 Triplex, 6-¾"x 10", 1,000 H.P., Powered by (2) Detroit B-60 Series Diesel Engines, Charged by (1) 5x6 Centrifugal Pump.

- **Mud Pump #2:** RS-F-1000 Triplex, 6-¾"x 10", 1,000 H.P., Powered by (2) Detroit B-60 Series Diesel Engines, Charged by (1) 5x6 Centrifugal Pump.
- **Rotary Table:** RGVP 275, 27-1/2".
- **Floorhand:** Blohm & Voss Oil Tools GF 110 0 Auto Floorhand Wrench & Spinner Combination.
- **Traveling Assembly:** Web Wilson 5 Sheave 250 Ton Block/Hook Combination and Oilwell PC 250 Ton Swivel.
- **Generators:** (2) Detroit Diesel B-60 Series Diesel Engines Driving (2) Marathon 250 KW Generators.
- **Mud System:** (1) Pit System, 550 Total Barrels, With Shaker, Volume, Mud Cleaning and Pill Mixing Compartments, Submerged Guns, (2) Centrifugal Pumps, (2) Flowline Cleaners and 2 Brandt Mud Agitators.
- **B.O.P.E.** Hydrill GK 13 -5/8", 3,000# Annular, Shaffer 13- 5/8 ", 3,000# D-Ram, CAD 120 Gallon Accumulator and 3,000# Choke Manifold.
- **Water/Fuel Storage:** 400 BBLS/3,000 Gallons.
- **Auxiliary Equipment:** (2) Air Winches, Wireline Unit (.092"), (2) Air Compressors, Crew Doghouse, Toolpusher Trailer.

I. EQUIPMENT RATING (HORSEPOWER)

Drawworks: Two Detroit B -60 Series Diesel Engines --- 665 HP each

Mud Pump #1: Two Detroit B-60 Series Diesel Engines --- 665 HP each

Mud Pump #2: Two Detroit B-60 Series Diesel Engines --- 665 HP each

Generators: Two Detroit Diesel B-60 Series Diesel Engines --- 665 HP each

Assume one backup engine for each application. The total horsepower is 5 x 665 HP.

II. OPERATING HOURS

$$OT = \sum_{n=1}^{1.5\text{months}} \frac{\text{Total Hours}}{\text{Month}} = 2040\ hr/year \text{ assuming } 85 \text{ drilling days}$$

III. EQUIPMENT THERMAL EFFICIENCY

Energy conversion factor (Table 4.2 API Compendium) on an HHV basis is 8,089 Btu/hp-hr and J input/J output is 3.179

IV. FUEL AND EMISSIONS

$$\mathrm{FC} = \mathrm{ER} \times \mathrm{LF} \times \mathrm{OT} \times \mathrm{ETT} \times \frac{1}{\mathrm{HV}}$$

FC annual fuel consumption (volume/yr)

ER equipment rating (hp) – Assumed 675 hp each

LF equipment load factor (fraction) – Assume 0.5

OT annual operating time (hr/yr) – 750 hr/year assuming one and one-half months

ETT equipment thermal efficiency – 8089 Btu_{input}/hp-hr_{output}

HV fuel heating value (energy/volume) – diesel – 139,000 Btu/gal

$$FC\ \frac{gal}{yr} = 675\ hp \times 0.5 \times 2040\ \frac{hr}{yr} \times 8089\ \frac{Btu}{hp-hr} \times \frac{1}{139{,}000\ \frac{Btu}{gal}} = 40066\ \frac{gal}{yr} \approx 19.6\ \frac{gal}{hr}$$

This is a little lower than the value for Figure 1, which would be about 30 gal/hr.

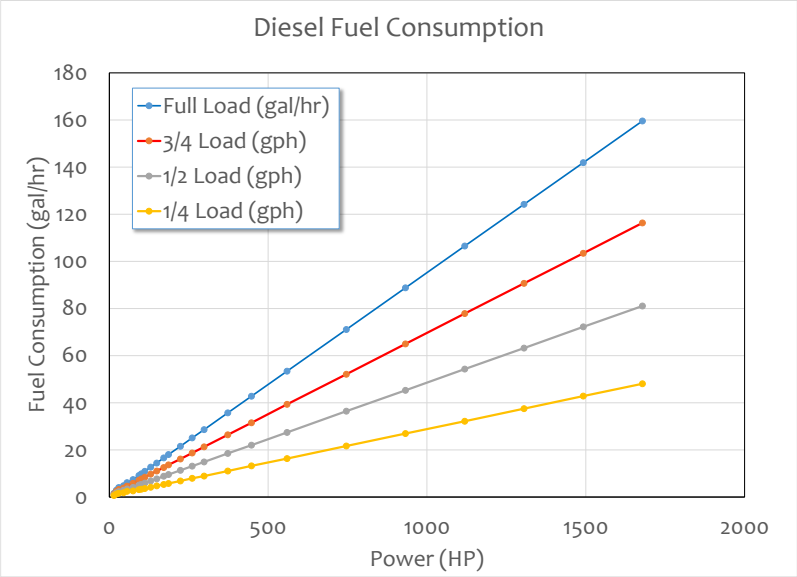


Figure 1. *Fuel consumption (after Müller, 2015)*[1]

If we multiply this by four potentially active diesel motors we get 19.6 gal/hr x 4 = 78.6 gal/hr which is not too dissimilar from published data.

> "The amount of No. 2 diesel (gallons) used to drill a well was averaged on a per hour basis for 85 electric rigs operating in the Eagle Ford Shale play throughout 2012. The resulting average was 55 gallons of diesel used per hour for a typical diesel Tier 2, 3512C Land Drilling Generator Set Engine. The gallons per hour (gal/hr) average was converted to pounds per hour (lb/hr) using average density for No. 2 diesel of 7 pounds per gallon (lb/gal) (API, 1988)."[2]

The average fuel usage per hour will then be:

$$\text{Average Fuel Usage} = 78.6\,\frac{\text{gal}}{\text{hr}} \times 7\,\frac{\text{lb}}{\text{gal}} = 550\,\frac{\text{lb}}{\text{hr}}$$

CO2 emissions were determined first using the API Compendium of Greenhouse Gas Emission Methodologies for the Oil and Natural Gas Industry, August 2009 (table appended). For gas/diesel oil the CO2 combustion emission factor is 20.2 kg C/10^9 J (LHV). This is approximated as 20.2 kg

---

[1] Müller, G.G. 2015. Development of an Energy Consumption Model Based on Standard Drilling Parameters, University of Leoben, June.

[2] Stuver, S. and Alonzo, J. 2016. Environmentally Friendly Drilling Systems Program, Texas A&M Institute of Renewable Natural Resources, December.

C/10^9 J (LHV) x 0.95 =19.2 kg C/10^9 J (HHV).For 100% carbon oxidation, the CO_2 emissions would be:

$$19.2\times10^{-9}\ \frac{\text{kgC}}{\text{J}}\times2.205\frac{\text{lb}_\text{m}}{\text{kg}}\times\frac{1\text{ J}}{0.0009478\text{Btu}}\times78.6\frac{\text{gal}}{\text{hr}}\times41\text{ days}\times24\frac{\text{hr}}{\text{day}}\times139{,}000\frac{\text{Btu}}{\text{gal}}$$
$$=479{,}954\text{ lb CO}_2=240\text{ ton CO}_2=218\text{ tonne CO}_2$$

Using the CARB data for Caterpillar 3512C Engines (shown in Table 1), emission factors can be determined. Next the total emissions can be determined as (NOx is shown as an example):

$$\text{E}\frac{\text{lb}_\text{NOx}}{\text{hr}}=\text{Fuel Usage}\frac{\text{lb}_\text{fuel}}{\text{hr}}\times\frac{1}{\text{BSFC}\frac{\text{lb}_\text{fuel}}{\text{hp}-\text{hr}}}\times\text{EF}_\text{NOx}\frac{\text{lb}_\text{NOx}}{\text{hp}-\text{hr}}$$

> "Based on interviews with drilling engineers, 50% load for Brake Specific Fuel Consumption (BSFC) of No. 2 Diesel on the 3512C drilling rig generator sets were considered most typical for a drilling operation in the Eagle Ford."[3]

The total emissions (based on 85 days of drilling) is then (again NOx is used as an example):

$$\text{E }lb_\text{NOx}=\text{E}\frac{\text{lb}_\text{NOx}}{\text{hr}}\times85\ days\times24\ hr$$

Table 3: *Emission Factors Available for Caterpillar 3512C Engines*

Emission Factor (g/kWh)/Standard	NMHC[3]	NOX	VOC	PM	CO
Caterpillar 3512C CARB	0.26	5.04	0.27	0.14	1.6
Caterpillar 3512C EPA	0.32	6.08	0.32	0.2	3.5
AP42 Controlled Engine >750 hp		7.91	0.43	0.43	3.35
AP42 Uncontrolled Engine >750 hp		14.6	0.43	0.43	3.35

Emission Factor (lb/hp-hr)/Standard	NMHC	NOX	VOC	PM	CO
Caterpillar 3512C CARB	4.28E-04	8.29E-03	4.44E-04	2.30E-04	2.63E-03
Caterpillar 3512C EPA	5.26E-04	1.00E-02	5.26E-04	3.29E-04	5.76E-03
AP42 Controlled Engine >750 hp		1.30E-02	7.07E-04	7.07E-04	5.51E-03
AP42 Uncontrolled Engine >750 hp		2.40E-02	7.07E-04	7.07E-04	5.51E-03

Table 4: *Estimated Emissions in lb/hr and over 85 days*

Emissions (lb/hr)	NMHC	NOX	VOC	PM	CO
Caterpillar 3512C CARB	0.29	5.60	0.30	0.16	1.78
Caterpillar 3512C EPA	0.36	6.75	0.36	0.22	3.89
AP42 Controlled Engine >750 hp		8.78	0.48	0.48	3.72
AP42 Uncontrolled Engine >750 hp		16.21	0.48	0.48	3.72
Emissions Over 85 Days (lb)	**NMHC**	**NOX**	**VOC**	**PM**	**CO**
Caterpillar 3512C CARB	588	11414	611	317	3623
Caterpillar 3512C EPA	725	13770	725	452	7925
AP42 Controlled Engine >750 hp		17914	974	974	7585
AP42 Uncontrolled Engine >750 hp		33065	974	974	7585

Table 4-3. CO_2 Combustion Emission Factors (Fuel Basis) for Common Industry Fuel Types

Fuel	Carbon Emission Factor from Original Source Document			CO_2 Emission Factor [a, b], US Units		CO_2 Emission Factor [a, b], SI Units	
	Emission Factor		Source [c]	tonnes/10^6 Btu (LHV)	tonnes /10^6 Btu (HHV)	tonnes /10^{12} J (LHV)	tonnes /10^{12} J (HHV)
Aviation Gas	18.87	MMTC/10^{15} Btu; Tg C/10^{15} Btu; kg C/MMBtu	Table 6-1, EIA, 2008; Table A-34, EPA, 2009; Table 12.1, TCR, 2008.	0.0728	0.0692	69.0	65.6
Bitumen	22.0	kg C/10^9 J (LHV)	Table 1.3, IPCC, 2007.	0.0851	0.0809	80.7	76.6
Coke	31.00	kg C/MMBtu	Table B-1, EPA, 2008; Table 12.1, TCR, 2008.	0.1199	0.1139	113.7	108.0
Coke (Coke Oven/Lignite/Gas)	29.2	kg C/10^9 J (LHV)	Table 1.3, IPCC, 2007.	0.1130	0.1073	107.1	101.7
Crude Oil	20.33	MMTC/10^{15} Btu; Tg C/10^{15} Btu; kg C/MMBtu	Table 6-1, EIA, 2008; Table A-34, EPA, 2009; Table 12.1, TCR, 2008.	0.0785	0.0745	74.4	70.7
Distillate Fuel (#1,2,4)	19.95	MMTC/10^{15} Btu or Tg C/10^{15} Btu; kg C/MMBtu	Table 6-1, EIA, 2008; Table A-34, EPA, 2009; Table 12.1, TCR, 2008.	0.0770	0.0732	73.0	69.3
Electric Utility Coal	No Data [c]		Table 6-1, EIA, 2008.	0.0997	0.0947	94.5	89.8
	25.76	Tg C/10^{15} Btu; kg C/MMBtu	Table A-35, EPA, 2009; Table 12.1, TCR, 2008.	0.0994	0.0945	94.2	89.5
Ethanol [d]	19.3	kg C/10^9 J (LHV)	Table 1.3, IPCC, 2007.	0.0747	0.0709	70.8	67.2
Flexicoker Low Btu Gas	278	lb CO_2/10^6 Btu (LHV)	Petroleum Industry Data.	0.1261	0.1135	119.5	107.6
Fuel Oil #4	45.8	lb C/10^6 Btu	Derived from fuel property data in Table 3-8.	0.0802	0.0762	76.0	72.2
Gas/Diesel Oil [e]	20.2	kg C/10^9 J (LHV)	Table 1.3, IPCC, 2007.	0.0781	0.0742	74.1	70.4
Jet Fuel	19.33	MMTC/10^{15} Btu; Tg C/10^{15} Btu; kg C/MMBtu	Table 6-1, EIA, 2008; Table A-34, EPA, 2009; Table 12.1, TCR, 2008.	0.0746	0.0709	70.7	67.2
Kerosene	19.72	MMTC/10^{15} Btu; Tg C/10^{15} Btu; kg C/MMBtu	Table 6-1, EIA, 2008; Table A-34, EPA, 2009; Table 12.1, TCR, 2008.	0.0761	0.0723	72.1	68.5
Lignite	26.30	MMTC/10^{15} Btu; kg C/MMBtu	Table 6-2, EIA, 2008; Table B-1, EPA, 2008; Table 12.1, TCR, 2008.	0.1015	0.0964	96.2	91.4
Liquefied Petroleum Gas (LPG)	No Data [c]		Table 6-1, EIA, 2008.	0.0656	0.0623	62.1	59.0
	17.23	kg C/MMBtu	Table B-1, EPA, 2008; Table 12.1, TCR, 2008.	0.0665	0.0632	63.0	59.9

ATTACHMENT 2

Pit volume constituents based on the drilling of one 7000 ft Well in Phase 2B. The calculated volumes are based on the proposed well design shown below.

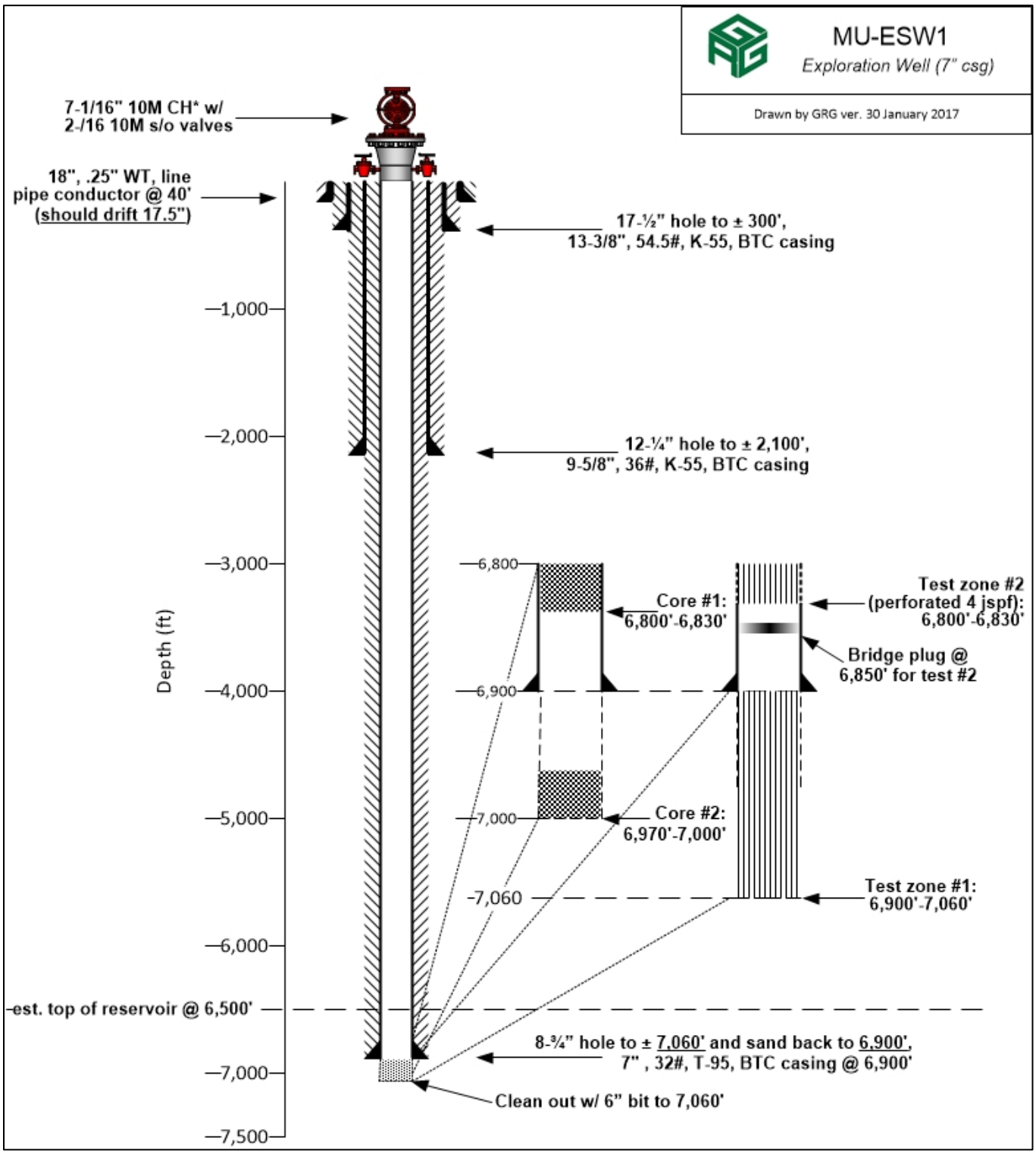
Cuttings Weight (10% Excess of Nominal Hole Size): ..... 332.5 (tonnes)

Bulked Cuttings Volume (30% Bulking Factor): .....5761 ft^3 (163 m^3)

Micronized Cellulose (3% of 2 Wellbore Volumes): .....266 ft^3 (7.53 m^3)

Water (2 Wellbore Volumes): ..... 8863 ft^3 (66,300 gal, 251 m^3)

Pit Volume:.....17461 ft^3 (130,618 gal, 494.5 m^3)


MU-ESW1
Exploration Well (7" csg)
Drawn by GRG ver. 30 January 2017
7-1/16" 10M CH* w/
2-/16 10M s/o valves
18", .25" WT, line
pipe conductor @ 40'
(should drift 17.5")
17-½" hole to ± 300',
13-3/8", 54.5#, K-55, BTC casing
12-¼" hole to ± 2,100',
9-5/8", 36#, K-55, BTC casing
Depth (ft)
1,000
2,000
3,000
4,000
5,000
6,000
7,000
7,500
6,800
6,900
7,000
-7,060
Core #1:
6,800'-6,830'
Test zone #2
(perforated 4 jspf):
6,800'-6,830'
Bridge plug @
6,850' for test #2
Core #2:
6,970'-7,000'
Test zone #1:
6,900'-7,060'
est. top of reservoir @ 6,500'
8-¾" hole to ± 7,060' and sand back to 6,900',
7" , 32#, T-95, BTC casing @ 6,900'
Clean out w/ 6" bit to 7,060'

ATTACHMENT 3

NOISE LEVELS

Typical rig noise was reported by Behrens and Associates, Inc. in a 2006 study in the Dallas Fort Worth area.[4] These are shown in Tables 1 through *. The ambient, pre-drilling noise ranged from 48 to 67 dBA depending on location and time of day. Table 1 shows drilling noise decaying rapidly to ambient with distance from the source. That being said:

"Drilling noise levels were measured in all four directions from the rig with measurable drilling rig noise recorded up to 700 feet from the drilling rigs. The drilling rig brake noise was audible up to 1,000 feet from the rigs. As can be seen in the following table, the average drilling sound level at 200 feet was 71 to 79 dBA."

"The brake noise narrow frequency band or "pure tone" is typically identified as the most problematic noise source generated by a drilling rig due to the clear audibility of the noise up to 1,000 feet from the rig. The brake noise is especially problematic during the nighttime, when other background noise levels become lower."

Table 1. *Noise levels during drilling.*

Distance (feet)	Noise Levels from Drilling Equipment in dBA			
	V Door Side of Rig	Generator Side of Rig	Mud Pit Side of Rig	Rear Side of Rig
100	80-82	84-87	75-77	78-81
200	73-77	75-79	71-73	73-76
300	65-73	70-74	67-69	68-70
400	60-70	63-71	60-68	61-68
500	57-61	59-68	56-59	58-60
600	54-58	55-59	54-58	55-59
700	51-54	52-53	51-54	52-55
800	51-54	51-54	51-54	

[4] Behrens and Associates, Inc. 2006. Gas Well Drilling Noise Impact and Mitigation Study, The Gas Well Drilling Task Force, Fort Worth, Texas, April.

Table 1 is represented further in Figure 1. Notice how the attenuation with distance to ambient levels is consistent with the theoretical relationship plotted in Figure 2.

Brake noise can be mitigated in urban environments, as shown in Table 2.

Table 2. *Brake Noise*

Measurement Distance in feet (from Drawworks)	Peak Brake Sound Level in dBA Before Mitigation	Peak Brake Sound Level in dBA After Mitigation
10	102-105	88-92
100	76-80	70-74
200	72-77	65-70
300	67-73	61-65
400	64-70	56-60
500	61-66	53-56

Noise levels for geothermal activities have also been reported by Patsa and Zarrouk, 2012.[5] Their measurements are shown in Table 3. In Table 3, LAeq is Equivalent Continuous or Time-Average A-Weighted Sound Pressure Level. When a noise varies over time, the LAeq is the equivalent continuous sound which would contain the same sound energy as the time-varying sound.

Table 3. *Maximum LAeq (Patsa and Zarrouk, 2012)*

Section Equipment	**LAeq [dB]**
Floor Drawworks	105.41
Generators Generators	104.8
Cementers Cementing Unit	104.3
Air Drillers Booster	101.4
Mud Tanks Water Pump	99.8

[5] Patsa, E., and Zarrouk, S. 2012. Noise from Geothermal Drilling, SEEP2012 Conference Proceedings, June 5th – 8th, Dublin, Ireland.

They also offered simple formulae. Hemispherical noise propagation near the ground is given by the following equations (SWL is the Sound Power Level).

$$\mathrm{SPL} = \mathrm{SWL} - 20\log \mathrm{r} - 8 \text{ dB}$$

SWL is the Sound Power Level and it is defined by:

$$\mathrm{SWL} = 10\log_{10} \frac{\text{Sound Power}}{\text{Reference Power} \rightarrow 10^{-12} \text{ watt}}$$

An even more interesting relationship is the inverse proportionality relationship that characterizes attenuation with distance.

$$L_{P2} = L_{P1} + 20\log_{10}\left(\frac{r_1}{r_2}\right)$$

Consider an example where the weighted sound pressure level from the drawworks at a distance of 10 feet is 105 dB. Figure 2 is an indication of how this signal varies with radial distance.

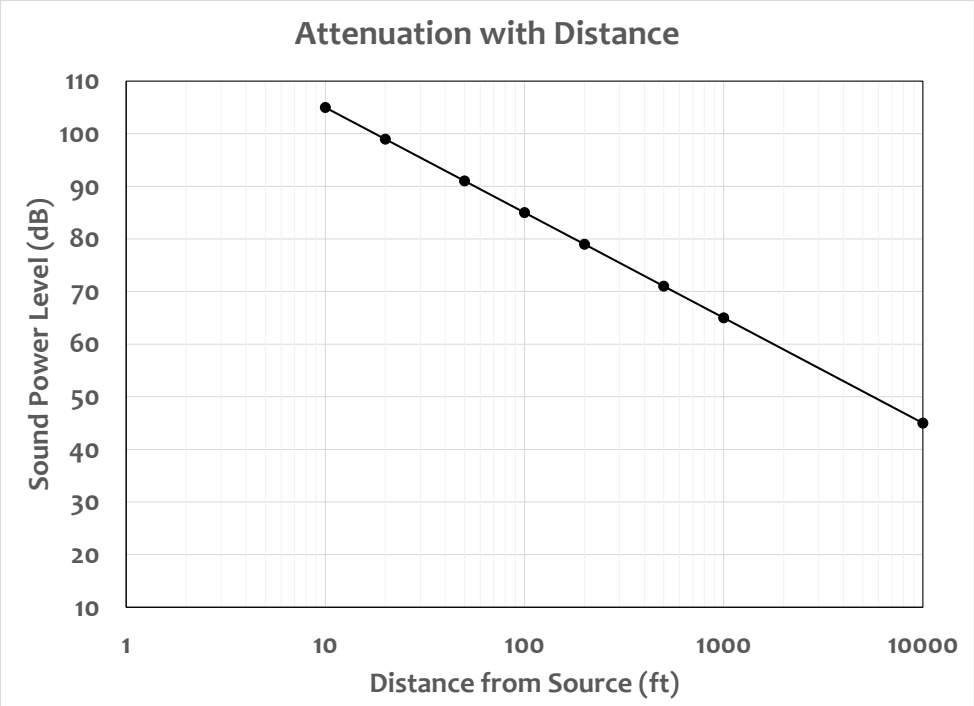


Figure 2. *Demonstration on how sound power level degrades with distance from the source. Recognize that the Utah FORGE environs are remote and unpopulated. Note the similarities to the measurements shown in Figure 1.*

Data were also made available from the DOE's recent measurements. Measurements are shown in Tables 3 through 6.

Table 3. *Hydraulic Fracturing in Marion Co. WV.*

Site A (near impoundment above pad)			Site C (near road)			Site D (1200 ft from pad)		
Time Above Sound Level (minutes)	Time Above Sound Level (%)	Sound Level (DBa)	Time Above Sound Level (minutes)	Time Above Sound Level (%)	Sound Level (DBa)	Time Above Sound Level (minutes)	Time Above Sound Level (%)	Sound Level (DBa)
53	0.36	90	6	0.04	90	3	0.02	90
191	1.29	80	52	0.35	80	19	0.13	80
644	4.34	70	930	6.26	70	138	0.93	70
2277	15.34	60	4949	33.32	60	658	4.44	60
4261	28.70	50	11331	76.3	50	2760	18.63	50
7353	49.53	40	12048	81.13	40	10028	67.68	40
14845	100	30	14851	100	30	14817	100	30

Table 4. *Hydraulic Fracturing, Wetzel Co., WV - Site B (next to road)*

Time Above Sound Level (minutes)	Time of Sound Level (%)	Sound Level (DBa)
1	0.01	90
15	0.1	80
134	0.9	70
1917	12.91	60
7221	48.64	50
8589	57.86	40
8589	57.86	30

Table 5. *Pad Preparation, Wetzel Co., WV*

Site 3A (near pad construction)			Site 3C (away from construction, near road)		
time above sound level (minutes)	% of time above sound level	sound level (DbA)	time above sound level (minutes)	% of time above sound level	sound level (DbA)
68	0.8	90	1	0.01	90
855	10.07	80	7	0.08	80
4046	47.63	70	242	2.85	70
7045	82.94	60	3336	39.27	60
8416	99.08	50	8202	96.56	50
8494	100	40	8482	99.86	40
8494	100	30	8494	100	30

Table 6. *Vertical Drilling (no activity) traffic noise Wetzel Co., WV, nad Vertical Drilling in Brooke County, WV.*

Site 2A (next to road/construction) Wetzel County				**Site 2C (far side of pad away from traffic) Wetzel County**			**Site C (next to road) Brooke County**		
time above sound level (minutes)	**% of time above sound level**	**sound level (DbA)**	**minutes of sound level**	**% of time of sound level**	**above sound level of (DbA)**	**sound level (DbA)**	**% of time of sound level**	**above sound level of (DbA)**	**sound level (DbA)**
1	0.01	90	11	13	0.18	90	11	0.09	90
254	3.48	80	70	134	1.84	80	70	0.54	80
5213	71.32	70	298	499	6.84	70	298	2.32	70
7304	99.93	60	862	927	12.71	60	862	6.71	60
7309	100.00	50	7297	6363	87.22	50	7297	56.78	50
7309	100.00	40	9118	7295	100.00	40	9118	70.95	40
7309	100.00	30	9118	7295	100.00	30	9118	70.95	30

ATTACHMENT 4

Table 1 shows the estimated emissions that would be generated during the drilling of two 11,500 ft wells. The procedures for the estimations are and rig specifications are presented in Attachment 1. It was assumed that the same rig would be used. The emissions were prorated based on the estimates for the 7000 ft well in 2B. Thus, each of the two Phase 3 wells would emit 1.4 times the emissions of the 7000 ft well.

Table 1. *Total emissions for drilling two 11,500 wells in Phase 3.*

CO_2 (ton)	NMHC (lb)	NOX (lb)	VOC (lb)	PM (lb)	CO (lb)
1404	1662	32230	1726	895	10232
CO_2 (tonne)	**NMHC (kg)**	**NOX (kg)**	**VOC (kg)**	**PM (kg)**	**CO (kg)**
1276	755	14616	784	403	4642

NMHC = non-methane hydrocarbons; NOX = nitrous oxides = VOC is volatile organic compounds; PM = particulate matter; CO = carbon monoxide.

The Utah FORGE team proposes to stimulate three zones at the toes of the deep wells to provide data necessary for the development of a stimulation research program and the he formation of the FORGE reservoir. The horsepower expenditure was estimated assuming 2 pumpers and 1 blender at 2700 HHP each and 600 HHP, respectively, in operation for 6 hours on each well. Alternatively, the horsepower estimate can be calculated assuming 5,000 psi at the surface and 50 barrels per minute; this is 6121 HHP. The two estimates are almost identical.

Assuming 6 hours of high pressure pumping on each well (12 hours total) and 6100 HHP, the emissions for the hydraulic fracturing are on the order of the values shown in Table 2.

Table 2. *Estimated emissions for hydraulic fracturing three zones in each of the two wells drilled in Phase 3.*

CO_2 (ton)	NMHC (lb)	NOX (lb)	VOC (lb)	PM (lb)	CO (lb)
4.84	5.42	111	5.94	3.08	35.23
CO_2 (tonne)	NMHC (kg)	NOX (kg)	VOC (kg)	PM (kg)	CO (kg)
4.39	2.6	50.34	2.70	1.39	15.98

NMHC = non-methane hydrocarbons; NOX = nitrous oxides = VOC is volatile organic compounds; PM = particulate matter; CO = carbon monoxide.

The emissions estimated included exhaust carbon dioxide (CO_2), carbon monoxide (CO), oxides of nitrogen (NOx), non-methane hydrocarbons (NMHC), volatile organic compounds (VOC), and Particulate Matter (PM) and compared with the recorded data by West Virginia University's (WVU) Center for Alternative Fuels, Engines and Emissions (CAFEE) [1]. The data were taken from a drilling rig (MSEEL site), which utilized three Caterpillar 3512B generator units, rated at 1101 kW. Figure 1 compares the estimated emission from phase 3 with the recorded data from MSEEL site.

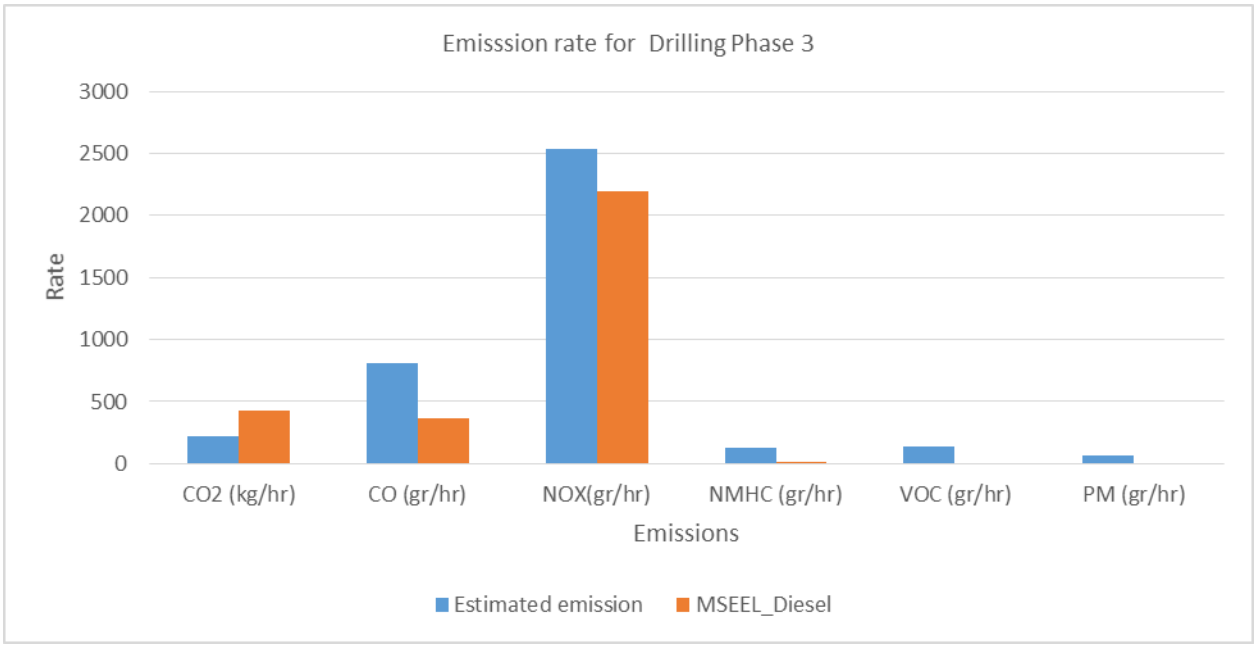


Figure 1. *Compression between estimated emission rate for phase 3 and the recorded data from MSEEL site [1]*

Reference

[1] Johnson, D., and Heltzel, R. (2015), “MSEEL Site: Engine Fueling and Emissions from a Caterpillar 3512B Generator Set”

ATTACHMENT 5

SUMMARY OF PIT VOLUME CONSTITUENTS FOR TWO 11,500 FT WELLS IN PHASE 3

Cuttings Weight (10% Excess):	1570 (tonnes)
Bulked Cuttings Volume (30% Bulking Factor):	27208 ft^3 (770.5 m^3)
Micronized Cellulose (3% of 2 Wellbore Volumes):	1256 ft^3 (35.56 m^3)
Water (2 Wellbore Volumes):	41858 ft^3 (313,119 gal, 1185 m^3)
Pit Volume:	82461 ft^3 (616,852 gal, 2335 m^3)

ATTACHMENT 6

NOISE LEVELS

Typical rig noise was reported by Behrens and Associates, Inc. in a 2006 study in the Dallas Fort Worth area.[6] These are shown in Tables 1 through *. The ambient, pre-drilling noise ranged from 48 to 67 dBA depending on location and time of day. Table 1 shows drilling noise decaying rapidly to ambient with distance from the source. That being said:

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200	73-77	75-79	71-73	73-76
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500	57-61	59-68	56-59	58-60
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700	51-54	52-53	51-54	52-55
800	51-54	51-54	51-54	

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[6] Behrens and Associates, Inc. 2006. Gas Well Drilling Noise Impact and Mitigation Study, The Gas Well Drilling Task Force, Fort Worth, Texas, April.

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Noise levels for geothermal activities have also been reported by Patsa and Zarrouk, 2012.[7] Their measurements are shown in Table 3. In Table 3, LAeq is Equivalent Continuous or Time-Average A-Weighted Sound Pressure Level. When a noise varies over time, the LAeq is the equivalent continuous sound which would contain the same sound energy as the time-varying sound.

Table 3. *Maximum LAeq (Patsa and Zarrouk, 2012)*

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They also offered simple formulae. Hemispherical noise propagation near the ground is given by the following equations (SWL is the Sound Power Level).

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SWL is the Sound Power Level and it is defined by:

$$\mathrm{SWL} = 10\log_{10} \frac{\text{Sound Power}}{\text{Reference Power} \rightarrow 10^{-12} \text{ watt}}$$

An even more interesting relationship is the inverse proportionality relationship that characterizes attenuation with distance.

$$\mathrm{L_{P2}} = \mathrm{L_{P1}} + 20\log_{10}\left(\frac{\mathrm{r_1}}{\mathrm{r_2}}\right)$$

Consider an example where the weighted sound pressure level from the drawworks at a distance of 10 feet is 105 dB. Figure 2 is an indication of how this signal varies with radial distance.

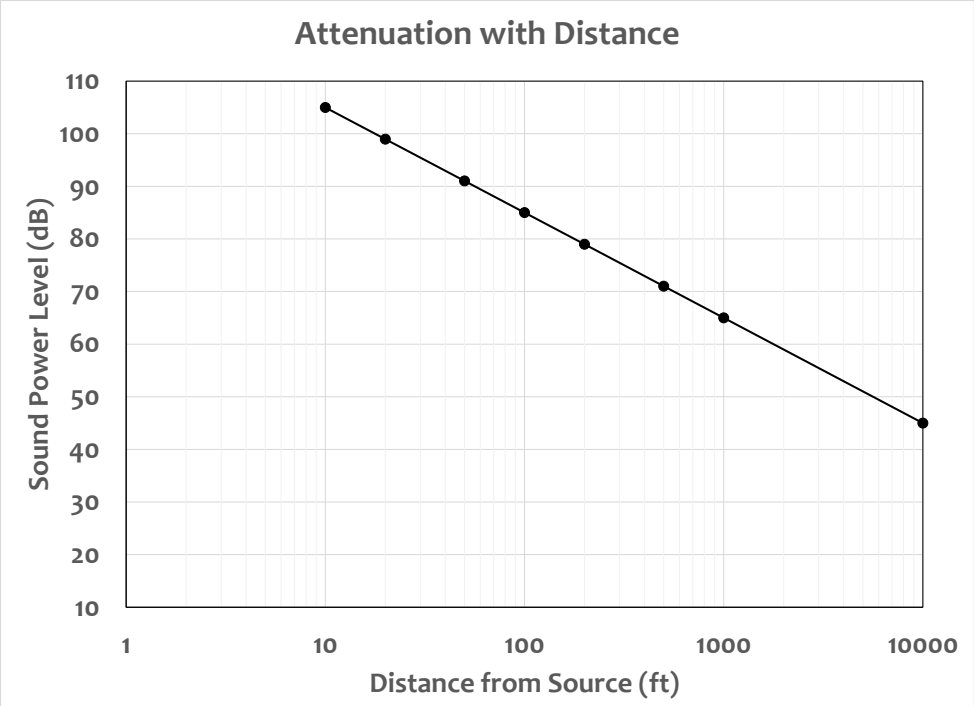

Figure 2. *Demonstration on how sound power level degrades with distance from the source. Recognize that the Utah FORGE environs are remote and unpopulated. Note the similarities to the measurements shown in Figure 1.*

Data were also made available from the DOE's recent measurements. Measurements are shown in Tables 3 through 6.

Table 3*. Hydraulic Fracturing in Marion Co. WV.*

Site A (near impoundment above pad)			**Site C (near road)**			**Site D (1200 ft from pad)**		
Time	***Time***	***Sound***	***Time***	***Time***	***Sound***	***Time***	***Time***	***Sound***
53	0.36	90	6	0.04	90	3	0.02	90
191	1.29	80	52	0.35	80	19	0.13	80
644	4.34	70	930	6.26	70	138	0.93	70
2277	15.34	60	4949	33.32	60	658	4.44	60
4261	28.70	50	11331	76.3	50	2760	18.63	50
7353	49.53	40	12048	81.13	40	10028	67.68	40
14845	100	30	14851	100	30	14817	100	30

Table 4. *Hydraulic Fracturing, Wetzel Co., WV - Site B (next to road)*

Time Above Sound Level (minutes)	Time of Sound Level (%)	Sound Level (DBa)
1	0.01	90
15	0.1	80
134	0.9	70
1917	12.91	60
7221	48.64	50
8589	57.86	40
8589	57.86	30

Table 5. *Pad Preparation, Wetzel Co., WV*

Site 3A (near pad construction)			Site 3C (away from construction, near road)		
time above sound level (minutes)	% of time above sound level	sound level (DbA)	time above sound level (minutes)	% of time above sound level	sound level (DbA)
68	0.8	90	1	0.01	90
855	10.07	80	7	0.08	80
4046	47.63	70	242	2.85	70
7045	82.94	60	3336	39.27	60
8416	99.08	50	8202	96.56	50
8494	100	40	8482	99.86	40
8494	100	30	8494	100	30

Table 6. *Vertical drilling (no activity) traffic noise Wetzel Co., WV, and Vertical drilling in Brooke County, WV.*

Site 2A (next to road/construction) Wetzel County				**Site 2C (far side of pad away from traffic) Wetzel County**			**Site C (next to road) Brooke County**		
time above sound level (minutes)	**% of time above sound level**	**sound level (DbA)**	**minutes of sound level**	**% of time of sound level**	**above sound level of (DbA)**	**sound level (DbA)**	**% of time of sound level**	**above sound level of (DbA)**	**sound level (DbA)**
1	0.01	90	11	13	0.18	90	11	0.09	90
254	3.48	80	70	134	1.84	80	70	0.54	80
5213	71.32	70	298	499	6.84	70	298	2.32	70
7304	99.93	60	862	927	12.71	60	862	6.71	60
7309	100.00	50	7297	6363	87.22	50	7297	56.78	50
7309	100.00	40	9118	7295	100.00	40	9118	70.95	40
7309	100.00	30	9118	7295	100.00	30	9118	70.95	30

ATTACHMENT 7

Table 1 presents the estimated quantities of gases and particulate matter that would be produced during the drilling of one 1000 ft water well in Phase 2C. Three wells are planned. The calculations assume the wells are drilled with a small truck mounted drill rig, a total of 30 days of drilling and that the emissions during the drilling of each well are 5% or less the emissions generated during the drilling of the 7000 ft well.

Table 1. *Total Emissions for 1000 ft water well drilled in Phase 2C.*

CO_2 (ton)	NMHC (lb)	NOX (lb)	VOC (lb)	PM (lb)	CO (lb)
75	88	1712	92	48	545
CO_2 (tonne)	NMHC (kg)	NOX (kg)	VOC (kg)	PM (kg)	CO (kg)
68	40	776	52	22	247

NMHC = non-methane hydrocarbons; NOX = nitrous oxides = VOC is volatile organic compounds; PM = particulate matter; CO = carbon monoxide.

ATTACHMENT 8

PIT VOLUME CONSTITUENTS BASED ON DRILLING TEN 500 FT SEISMIC HOLES IN PHASE 2C

For one well:

Cuttings Weight (10% Excess of Nominal Hole Size):..... 8.1 tons (7.3 tonnes)

Bulked Cuttings Volume (30% Bulking Factor):..... 192 ft^3 (5.4 m^3)

Water (2 Wellbore Volumes):..... 269 ft^3 (7.61 m^3)

Pit Volume (per well):..... 363 ft^3 (10.3 m^3)

Based on 20% average porosity

For ten wells:

Cuttings Weight (10% Excess of Nominal Hole Size):..... 80.7 tons (73.3 tonnes)

Bulked Cuttings Volume (30% Bulking Factor):..... 1922 ft^3 (54.4 m^3)

Water (2 Wellbore Volumes):..... 2688 ft^3 (76.1 m^3)

Pit Volume (per well):..... 363 ft^3 (10.3 m^3)

Based on 20% average porosity

ATTACHMENT 9

Table 1 presents the estimated quantities of gases and particulate matter that would be produced by diesel engines during the drilling of ten 500 ft seismic bore holes in Phase 2C. The calculations assume the wells are drilled with a small truck mounted drill rig, a total of 60 days of drilling and that the emissions during the drilling of each well are 5% or less the emissions generated during the drilling of the 7000 ft well.

Table 1. *Total Emissions produced during drilling in Phase 2C*

CO_2 (ton)	NMHC (lb)	NOX (lb)	VOC (lb)	PM (lb)	CO (lb)
125	147	2854	153	80	906
CO_2 (tonne)	**NMHC (kg)**	**NOX (kg)**	**VOC (kg)**	**PM (kg)**	**CO (kg)**
113	67	1294	70	36	411

NMHC = non-methane hydrocarbons; NOX = nitrous oxides = VOC is volatile organic compounds; PM = particulate matter; CO = carbon monoxide.

ATTACHMENT 10

PIT VOLUME CONSTITUENTS BASED ON THE DRILLING TEN 500 FT SEISMIC HOLES IN PHASE 2C

For one well:

Cuttings Weight (10% Excess of Nominal Hole Size): ..... 8.1 tons (7.3 tonnes)

Bulked Cuttings Volume (30% Bulking Factor): ..... 192 ft^3 (5.4 m^3)

Water (2 Wellbore Volumes): ..... 269 ft^3 (7.61 m^3)

Pit Volume (per well): ..... 363 ft^3 (10.3 m^3)

Based on 20% average porosity

For ten wells:

Cuttings Weight (10% Excess of Nominal Hole Size): ..... 80.7 tons (73.3 tonnes)

Bulked Cuttings Volume (30% Bulking Factor): ..... 1922 ft^3 (54.4 m^3)

Water (2 Wellbore Volumes): ..... 2688 ft^3 (76.1 m^3)

Pit Volume (per well): ..... 363 ft^3 (10.3 m^3)

Based on 20% average porosity

ATTACHMENT 11

The proposed plan calls for the drilling and stimulation of two deep, 11,500 ft wells and stimulation and of three zones at the toe of the wells. The proposed R and D program could include stimulation of up to 20 stages within each well. Table 1 shows the estimated emissions that would be generated during the stimulation of 20 zones in the deep production/injection wells. By comparison, the estimates for the stimulation of three zones are shown in Table 2, Attachment 4.

Table 1. *Estimated emissions for hydraulic fracturing 20 zones in each of the two wells drilled in Phase 3.*

CO_2 (ton)	**NMHC (lb)**	**NOX (lb)**	**VOC (lb)**	**PM (lb)**	**CO (lb)**
32.3	36.1	740	39.6	20.5	235
CO_2 (tonne)	**NMHC (kg)**	**NOX (kg)**	**VOC (kg)**	**PM (kg)**	**CO (kg)**
29.3	17.3	336	18	9.3	107

NMHC = non-methane hydrocarbons; NOX = nitrous oxides = VOC is volatile organic compounds; PM = particulate matter; CO = carbon monoxide.